THE

Indian Tea Association

SCIENTIFIC DEPARTMENT

QUARTERLY JOURNAL

PART IV

1931

Calcutta
PRINTED AT THE CATHOLIC ORPHAN PRESS
3 & 4 Portuguese Church Street

1932

THE

Indian Tea Association

SCIENTIFIC DEPARTMENT

QUARTERLY JOURNAL

PART IV

1931

CONTENTS

	Page
Essential Garden Work and possible Economies ...	159
Effect of Manuring on Soil Tilth	185
Caterpillar Pests of the Tea Plant, and of Green Manure Plants and Shade Trees in use on Tea Estates	189
Touring Programme 1932	203
Index	204

ESSENTIAL GARDEN WORK AND POSSIBLE ECONOMIES

BY

H. R. COOPER.

Part 2.

Manuring for Maintenance.

In the last number of this Journal the necessity of maintaining a reasonably good yield per acre was discussed, and the opinion was expressed that in order to produce at a sufficiently low cost, not only must good standards of cultivation and pruning be kept up as economically as possible, but the fertility of the soil must not be allowed to drop to too low a level. Where good tea has been established on good normal soil, it may yield very well for say ten or fifteen years with no food other than that supplied by the soil so long as cultivation and pruning are efficient; but by that time, if not before, tea without food from outside sources deteriorates, and under such circumstances, deterioration, once it starts, is usually rapid. Some form of manuring is a necessity, either to prevent deterioration or to restore unremunerative areas to a profitable level of production.

In the following discussion, use is made of results hitherto unpublished in detail, because it is considered that it is a matter of urgency to place our opinions before the Tea Industry, in view of the present situation. Detailed accounts of the evidence supporting these views will appear in the Annual Report.

The essential elements.

For all crops, even those grown for fruit or seed, nitrogen is the constituent of a manure which is of chief importance. For

crops which, like tea, are grown for leaf, nitrogen is of still greater importance, while potash and phosphoric acid are of greatly less importance.

Experiment at Borbhetta, indeed, has shown that 40 lbs. nitrogen per acre when used alone gave a 25% increase in crop in the first year of application, and that the use of 15, 30 or 60 lbs. potash, or 15, 30 or 60 lbs. of phosphoric acid per acre, or of eight of the nine possible combinations of the above quantities of potash and phosphoric acid together with 40 lbs. nitrogen, gave no more crop than did 40 lbs. nitrogen alone. This is on a soil naturally very poor in phosphoric acid and potash, (by any analytical standard), and on tea grown unmanured for 9 years and pruned and plucked hard for the last six years, so that a need for additional potash and phosphoric acid might have been expected.

It is considered that when only small dressings of nitrogen are used, it will be safe to conclude that most, if not all, tea soils may be left without potash or phosphoric acid for at least one year and probably for several years. The fact that cases are known, on estates, where yields of 10 mds. per acre have been maintained for many years, without other manure than that provided by leaf fall from shade trees, confirms the small need of tea for manures other than nitrogen. Leguminious shade trees would provide additional nitrogen from the air, but no potash or phosphoric acid other than that originally taken from the soil, so that they cannot enrich the soil in these constituents although they may (and probably do) increase their availability as plant food.

Where heavy dressings of nitrogen are given, relatively heavy dressings of potash and phosphoric acid may be necessary to get full value from the nitrogen applied. For example at Borbhetta, 120 lbs. nitrogen, with 30 lbs. potash and 30 lbs. phosphoric acid applied annually since 1925 produced in 1930 a crop of 16½ mds. tea, little more than was obtained from 60 lbs. nitrogen with either 30 lbs. or 60 lbs. each of potash and

phosphoric acid; but 120 lbs. nitrogen together with 120 lbs. potash and 120 lbs. phosphoric acid gave 19 mds. per acre. The effect of deficiency in potash and phosphoric acid showed up in the first year of manuring.

In another experiment, 120 lbs. nitrogen together with only 60 lbs. potash and 60 lbs. phosphoric acid gave three times as much crop increase as did 40 lbs. nitrogen with 20 lbs. potash and 20 lbs. phosphoric acid, both in the first and in the second year of manuring, so that this ratio of nitrogen to phosphoric acid to potash is sufficient for this soil, at any rate.

It appears that it is necessary to ensure that sufficient potash and phosphoric acid are available to the tea, to balance the nitrogen obtainable. When large dressings of nitrogen are used it appears to be sufficient to use potash and phosphoric acid in quantities each equal to half that of the quantity of nitrogen used. When only moderate dressings of nitrogen are applied as manure, the soil can supply as much potash and phosphoric acid as are necessary to allow full use of the nitrogen. At the present time, when every economy is essential, this fact should be made use of, and the cost of potash and phosphoric acid saved for at least one year. When the Borbhetta plots begin to show loss from deficiency of these substances, the question can be reconsidered.

This will effect a quite considerable economy. In former years it has been customary to use mixtures supplying nitrogen, phosphoric acid and potash in roughly equal quantities, in order that, in the absence of information on the subject, one might be on the safe side.

The free use of potash and phosphoric acid was the more readily advised since in former years their cost was small compared to that of the nitrogen used. Artificial forms of nitrogen have lately fallen in price much more than have potash and phosphoric acid manures. The cost of the latter is now no small consideration.

For example a formerly common mixture providing the cheapest nitrogen supply sufficient only for maintenance of fair yield would cost at present prices :—

	Supplying lbs. per acre.		
	Nitrogen.	Phosphoric acid.	Potash.
150 lbs. sulphate of ammonia	30	...	...
150 ,, ordinary superphosphate ...	...	30	...
60 ,, muriate of potash ...	...	...	30

at recent quotations this would cost :—

150 lbs. sulphate of ammonia	@	Rs.	122	per ton	=	Rs.	8	3
150 ,, ordinary superphosphate ...	,,	,,	75	,,	=	,,	5	0
60 ,, muriate of potash	,,	,,	145	,,	=	,,	3	14
360 lbs. mixture					@	Rs.	17	1

It will be seen therefore that this new knowledge makes possible the saving, for one year at least and probably for more, of about half the cost of former manuring programmes : while for future programmes it appears that it will always be safe to reduce the cost of the potash and phosphoric acid supplied to about Rs. 4/8- at most, instead of Rs. 9/-.

The evidence so far put forward relates to crop only, and not to quality.

Mann made a suggestion that potash and phosphoric acid had some effect in improving quality. This suggestion was based on the fact that he found more potash and phosphoric acid in the better than in the poor teas which he analysed. It is quite possible that the higher contents in the better teas were due to these having been made from finer leaf. No manurial trials of the effect of potash and phosphoric acid on quality were reported.

The leaf from the plots at Borbhetta on which the use of potash, or phosphoric acid, or both, made no difference to crop, was analysed on three occasions during 1931. No difference in content of potash or phosphoric acid, or nitrogen or of tannin, or of total soluble solids or ash or moisture content could be detect-

ed, whether 40 lbs. nitrogen was given alone or accompanied by 60 lbs. potash, 60 lbs. phosphoric acid or 60 lbs. of each. Difference in quality is therefore unlikely.

Leaf also was separately manufactured from plots receiving 120 lbs. nitrogen, 120 lbs. potash and 120 lbs. phosphoric acid, and from plots receiving 120 lbs. nitrogen, 30 lbs. potash and 30 lbs. phosphoric acid. The latter was preferred, possibly because it was giving the smaller crop.

While the question of the effect of potash and phosphoric acid on quality still remains to be settled definitely, it appears that, when only moderate doses of nitrogen are used, no change in quality is likely whether potash or phosphoric acid or both be used or not.

A large number of trials at Borbhetta have shown that moderate increase of crop from manuring has occasioned no detriment to quality, (in fact the tea from moderately manured tea has generally been preferred), while very heavy manuring (120 lbs. nitrogen per acre), has led to a slight deterioration in liquors, though usually an improvement in appearance. These trials were made with plucking at seven days interval, and with the same degree of fineness for manured and unmanured. It appears quite clear, from results in practice, that manuring has commonly led to improved quality by enabling a good crop to be made with an improvement in the standard of plucking, so long as sufficient labour is available that plucking is strictly fine and at close intervals on the manured tea.

For results either in maintenance or in improvement of crop it is quite clear from evidence from all sources, that nitrogen supply is the factor of overwhelming importance. One of the chief problems of the tea industry has been, and more than ever is now, the economical supply of nitrogen to the soil.

Nitrogen may be supplied in many forms, the merits of which will now be discussed.

Shade Trees.

If good leguminous shade trees have been established, so that the soil is enriched by fallen leaves with a high content of nitrogen, much of which has been obtained from the air, then in many cases steady yields of 10 mds. good tea per acre have been maintained for many years without any other source of food.

In fact it is probably not overstating the value of shade trees on normal soils, (*e.g.*, bheel soils must be excepted) to say that, in the plains, yields of at least 8 mds. per acre of good tea should be maintained with no other manure than shade trees; so long as no serious disease is present and vacancies and non-yielding bushes have not been allowed to exceed ten per cent., which, if "bad patches", be included, is so common a percentage as to be looked upon as almost normal.

Shade trees have many disadvantages, (some of which are very real though more are commonly exaggerated) but none of them are serious drawbacks to the use of leguminous trees so long as the shade is not excessive. If it is excessive, quality suffers seriously, and diseases (mosquito blight for example) may be intensified; while if it is very excessive crop also suffers. Roughly 50 ft. seems to be about the best distance apart. It is the custom of planting much closer, and allowing self-sown trees further to thicken the shade, which has lost shade trees much of their popularity, in many districts.

The use of shade trees is considered to be the cheapest method of maintaining a fair yield. If they had always been established, and maintained (replanting when necessary) we should not now have those large areas of unremunerative tea which have absorbed the profits made by the better areas in the cases of many companies producing lower grades of tea.

Unfortunately it is only at least four years after planting that shade trees give any significant benefit, and even then it may be slow to show up noticeably. Shade trees are more useful in maintaining a good soil with good tea on it, than in recovering poor tea. Where the tea is already poor, it is usually the case

that the soil has become so poor that efficient shade trees cannot be established without manuring. In any case something more rapid is necessary to deal with a case of emergency.

Green Crops.

At the present time, green crops are being very commonly looked to as a means of improvement or maintenance of the soil. This is partly because they are looked upon as "natural", and therefore less to be feared than artificials, either with regard to possible deterioration of quality, or with regard to the possibility of over-forcing growth with following deterioration of the tea.

It will be explained later that there is no evidence whatever to support either fear, and very much to indicate that the extra growth obtained from the cheapest and most efficient artificial will have exactly the same effect on quality or on the health of the bush, as extra growth from the use of green crops, or any other form of manure.

There is much more in the argument that most of the expenditure on green cropping goes in payment of labour, which in any case must be kept employed. Where there is no more remunerative work for the labour, the use of green crops may be very profitable; but it behoves every manager to consider how their use suits his own circumstances.

Green crops may be divided into two classes: the quick growing ground crops and the semi-permanent bushes.

Ground green crops. Cowpeas may be taken as the best example, generally, of this class. Normally, sowing should start about mid-March and finish about the end of April: there is commonly ample labour for this work. Hoeing-in should start about the beginning of May and finish not later than early June: on many gardens there may be enough labour to deal with large areas of this work also. All this time from mid-March to mid-June jungle is growing rapidly, and if the use of green crops withdraws so much labour from light cultivation that any considerable portion of the garden is weedy at the end of June, it

is probable that the effect on the yield and health of the tea will be worse than if no green crops had been grown. In no case should more green cropping be undertaken than will allow the maintenance also of a clean garden. A further disadvantage of ground green crops is that they reduce the yield of the tea while they are growing and for a short time afterwards. Although this loss is normally more than made up afterwards, a proportion of the valuable second flush tea is lost, and this loss may not be outweighed by the gain in the quantity of rains tea, even if it all can be plucked. A minor disadvantage of ground green crops is that they will not grow among high tea really covering the ground, but such tea will not be causing any present anxiety particularly if it is shaded.

It will be seen therefore that there are disadvantages to be set against the advantages of ground green crops, and their cost is not generally very small. Costs vary in different districts, but a probable minimum would be, per acre :—

½ md. seed with freight	...	Rs. 2-8-0
Preparation of seed bed and sowing and covering seed	...	,, 2-0-0
Extra cost of burying above that of ordinary light hoe	...	,, 1-8-0
	Total	Rs. 6-0-0

Frequently it would be necessary to use some manure to get reasonable growth. Even if only a little cheap mineral phosphate were used, this would add about Rs. 4/- to the cost, and this manure would not always be necessary for the tea if no green crops were used.

The green stuff after six weeks' growth contains about 0.4% nitrogen. Crops of 5 tons per acre are frequently reported, but the general average is probably not above 2½ tons per acre over the whole area sown. In that case, the green stuff hoed in contains 22 lbs. nitrogen per acre, only part of which came from the air : the remainder is simply returned to the soil from which it came, and the richer the soil (and better the crop) the less is the

proportion of nitrogen the green crop actually gained from the air. Even assuming that the whole 22 lbs. nitrogen were added to the soil by the green crop, this quantity of nitrogen could be purchased in the form of sulphate of ammonia for about Rs. 6/-, and including freight and application, could be applied to the soil for about Rs. 7/8- with greater efficiency and without any of the drawbacks attending the use of green crops.

Apart from the nitrogen the organic matter of the green crop has some value, but in the case of tea supplying several tons of prunings to the soil annually this value is apparently slight. At present low prices of artificials therefore it is believed that the use of ground green crops does not generally pay.

Semi-permanent green crops. Of these "boga medeloa" (*Tephrosia candida*) may be taken as about the best example.

It remains healthy and vigorous in the plains of North East India for two years. During this time it should be lopped at intervals, and 5 tons per acre may be taken as probably a conservative estimate of the total green stuff as loppings and leaf-fall added to the soil, in 2 years, from hedges sown in alternate lines among tea bushes sufficiently wide apart to leave room for growth. The soft green stuff (excluding woody stalk) contains about 1% nitrogen. This is on the green leaf as cut, not on the dry weight. It is again impossible to guess how much of this came from the soil, and how much represents fresh addition to the soil from the air; but of the 112 lbs. total nitrogen in 5 tons of green stuff a considerable portion must represent fresh addition. Again costs should be estimated for each individual garden, but a probable average would be about :—

¼ md. seed @ Rs. 20/- per md.	...	Rs. 5-0-0
Preparation of seed bed in alternate lines	...	,, 2-8-0
Sowing and covering seed	...	,, 1-0-0
Lopping during two years	...	,, 8-0-0
	Total	Rs. 16-8-0

No manuring generally is necessary to grow boga medeloa.

The last lopping at the end of two years should leave bare woody stems, which ought to be removed from the land. If the garden is short of firewood this is usually done without cost : on other gardens, the cost should be added to the above total. If seed is grown on the garden, as is usually the case, the above estimate will be reduced.

Generally, the cost of growing boga medeloa may be considered roughly equal to that of applying about 45 lbs. nitrogen per acre as sulphate of ammonia. Among tea such that reasonable space remains for the development of the boga medeloa, the boga medeloa probably offers the better value, and it has the further advantage of assisting materially to suppress jungle by its shade.

Boga medeloa is therefore considered to be of enormous value among poor to medium tea, not only in arresting deterioration, but in starting definite improvement.

If sown in hedges it need not interfere with cultivation. The seed rate of 20 lbs. per acre should give a thick stand in the single line sown. When about a foot high it should be thinned out to leave plants about 6″ apart, the thinnings being thrown to the next line to be turned in by the next hoe. All the time, the hoe can be used between the tea and very close to the boga medeloa.

The chief disadvantage attending its use is the necessity for lopping in the plucking season, but on many gardens labour unable to pluck is available for the work. Among really good wide bushes there is not sufficient room for good growth, crops of boga medeloa are poor, and among such tea the presence of what does grow hinders plucking and supervision ; so that its use is not desirable among good tea which is required to be plucked really well. For maintenance or improvement of such tea artificials must be used.

As far as efficiency of supply of nitrogen to the soil is concerned, it is clear therefore that there are limitations to the usefulness of leguminous plants grown among tea. Trees are

generally of value, but may be too slow in bringing an unprofitable area into profitable bearing. Shrubs like boga medeloa are of great value between tea bushes among which there is space for growth; but are generally undesirable in good tea, while they require labour when it is not easily spared. Ground green crops are believed generally not to pay in comparision with artificials at their present low prices.

Direct addition of nitrogen compounds carried from outside the area is therefore generally essential.

Locally available forms will first be discussed.

Cattle manure.

This fertilizer has always been considered of great value. It contains a fair percentage of nitrogen (about .4 to .6% on the material as collected from lines and villages) and therefore a very moderate application of 5 tons per acre provides at least 40 lbs. nitrogen per acre, which, in efficient form, would be considered a good dressing.

During the season 1931 its effect has been tried at Borbhetta with the following results :—

Manure per acre.	Yields mds. tea per acre.	Increase due to manure.
No manure	10·04	.....
5 tons cattle manure (providing 40 lbs. nitrogen) ...	10·56	·52 mds. or 5%
10 tons cattle manure (providing 80 lbs. nitrogen) ...	11·10	1·06 mds. or 10%
20 tons cattle manure (providing 160 lbs. nitrogen) ...	12·27	2·23 mds. or 22%

It will be observed (as also has been found in the case of sulphate of ammonia) that the increase in crop is about proportional to the quantity of manure applied so that it may be assumed that all the nitrogen which became available was used.

These experiments were performed on 24 plots in the middle of the 9-acre block of Tingamira tea all planted from the same nursery in the cold weather 1921-22.

The plots to one side of these 24 plots were used for experiment on different forms of nitrogen all supplying 40 lbs. nitrogen per acre. Among these was sulphate of ammonia which gave 11.22 mds. tea against 8.93 mds. from the unmanured check plots, an increase of about 25%.

The plots on the other side of the cattle manure plots were used for experiments on the use of 40 lbs. per acre nitrogen as sulphate of ammonia alone and accompanied by 14 different combinations of potash and phosphoric acid. All the manured plots gave 13.48 mds. tea per acre (well within experimental error) whether potash, phosphoric acid or both were used or not. The unmanured plots gave 10.85 mds. tea per acre. In this case also 40 lbs. nitrogen has given about 25% increase.

On a further set of plots at some distance away, 40 lbs. nitrogen gave 6.94 mds. tea per acre against 5.56 mds. from the unmanured check plots : again an increase of about 25%.

In season 1931, then, 40 lbs. nitrogen as sulphate of ammonia gave 25% increase, while in the same season on similar soil, cattle manure providing 40 lbs. nitrogen per acre gave 5% increase only.

The 20 tons cattle manure per acre providing 160 lbs. nitrogen per acre gave less increase than 200 lbs. sulphate of ammonia providing 40 lbs. nitrogen per acre.

We may say, then, that nitrogen in the form of cattle manure, has not more than a quarter of the efficiency of nitrogen in the form of sulphate of ammonia, in the first year of application. A greater residual value would be expected from the cattle manure ; but, while no experiments on this point yet exist, it has appeared from general practice that the residual effect in the soil is very small even in the second year, though it may extend over several years.

200 lbs. sulphate of ammonia, at the present price of Rs. 122/- per ton, cost about Rs. 11/- in Calcutta, so that with freight and application it may be applied generally at about Rs. 14/- per acre.

The cost of collecting and applying 5 tons of cattle manure (with one quarter of the efficiency) would generally exceed Rs. 14/- per acre.

Line-cleaning is a necessity and manure so collected should be used; but, contrary to expectations previous to actual trial, it will not pay generally to buy cattle manure.

Very long-continued experiments on other crops in other countries, have proved that land fed with artificials alone, eventually fails to maintain the fertility obtainable from the use of cattle manure in sufficient quantity. This is believed to be due to the presence of substances in the cattle manure which, in minute quantities only, are necessary for growth and are not present in the artificials. It is well, therefore, to make a practice of using small quantities of cattle manure occasionally to guard against this cause of eventual deterioration.

Top-dressing.

No definite trials with such material have been made, but it is improbable that the value of its nitrogen can greatly exceed that of cattle manure.

The real "leaf-mould" of peat-bheel containing ½% or more of nitrogen would certainly be worth application where the carry is so short that 10 tons can be applied for about Rs. 20/-, but ordinary rich soil (say ¼% nitrogen), such as that from many *hullahs* in Assam, is unlikely to be worth as much as cattle manure.

Cut green leaves.

Ordinary green leaf of any jungle trees contains about ⅓% nitrogen, which has been shown to be readily available as manure if only succulent green parts, without woody stem, be used. To cut, carry about 200 yds. and apply, costs at Borbhetta, about Rs. 5/- per ton. About 5½ tons at a cost of about Rs. 27/8/- would provide about as good a dressing as 200 lbs. sulphate of ammonia costing, applied, about half as much. Green jungle cannot therefore be recommended for general use;

but in places where it can be applied cheaply it may sometimes prove useful. If standing boga medeloa is near at hand only about 1¾ tons of its green stuff will provide equal effect, and this work would pay very well.

Artificial Manures.

While the above "natural manures" may occasionally prove useful, yet with the exception of leguminous trees they cannot be advised for general use, over a whole garden.

For application on a large scale, the manures classed as artificial, (because they have undergone some degree of preparation) must be used.

As previously explained, only those providing nitrogen need be dealt with in detail here.

With regard to the relative efficiencies of various artificials, several trials have been made at Borbhetta.

The most accurate, because each trial was repeated seven times, on relatively very even blocks of tea, was made in 1931. All manures were applied, after analysis of the sample used, to supply 40 lbs. nitrogen per acre. The following results were obtained :—

Manure used.	Yields in mds. tea per acre.	Gain compared to no manure.
1. No manure	8·93	.....
2. Dried blood	10·60	1·67
3. Oilcake	11·06	2·13
4. Cyanamide	10·98	2·05
5. Chloride of ammonia	11·16	2·23
6. Sulphate of ammonia	11·22	2·29
7. Nitrate of soda	11·17	2·24

The gains are the same (within experimental error) for all these forms of nitrogen, except dried blood, which gives a return just significantly less. It will be observed that the sample of oilcake, unlike the other organic manure (dried blood) has proved as efficient as the soluble artificials. This sample was produced by a modern press leaving little oil in the cake. Previous trials with less efficiently pressed cake (containing 15% oil) showed much less favourable results.

The times when the increases were made are of interest, because it is often assumed that the soluble artificials exert a very great early effect which afterwards falls away, while organic manures are often said to exercise a more steady effect throughout the season. The following four examples of commonly used manures show what actually occurred.

Manure.		Increased crop in mds. tea per acre compared to no manure.		
		To end July.	Aug. and Sept.	Oct. and Nov.
Soluble artificials	Nitrate of soda ...	·71	·97	·56
	Sulphate of ammonia...	·62	·93	·73
Organic manures	Oilcake	·53	·83	·77
	dried blood ...	·40	·73	·54

The dried blood has simply proved less efficient than the other manures throughout the season, even at the end.

The oilcake (containing little oil) loses a little compared to sulphate of ammonia up to the end of September, and makes up at the end of the season rather less than it lost earlier.

The nitrate of soda starts better than the others, but does fall away a little at the end of season. The season was probably unusually unfavourable to this manure. Such heavy rain fell that no additional nitrate could be detected in the soil three weeks after application; yet, even so, the effect on crop is very distinct right up to the end of the season.

There is very little in it with regard to the manner of action of all the manures used. At the most recent quotations, the costs of the applications are (excluding freight and application) :—

260 lbs.	nitrate of soda	@ Rs. 170-0 per ton	= Rs.	19- 2
216 „	calcium cyanamide	„ „ 110-0 „ „	= „	10-10
195 „	sulphate of ammonia	„ „ 122-0 „ „	= „	10-10
850 „	oilcake	„ „ 1-8 per md.	= „	15-15
360 „	dried blood	„ „ 180-0 per ton	= „	28-14

Chloride of ammonia is not now quoted. Since it is used for purposes other than manuring, it has to pay duty on entering India.

Blood meal. The very expensive animal protein (blood meal) has proved at best no better than the cheaper manures.

Oilcake (rape). The other organic manure, oilcake, at the price at which obtained locally was cheaper than nitrate of soda and gave about the same total effect, with the increases better distributed over the season. When good, not over-oily samples are obtainable locally at about Re. 1/- per maund, as has been possible lately, oilcake offers good value, particularly since it contains, in addition to about 4½% nitrogen, about 2% potash and 1% phosphoric acid, in addition to some organic matter.

In Calcutta however rape-cake is now quoted at Rs. 5/- per 2 md. bag, at which price its use cannot be recommended.

For gardens which still insist on an organic manure and cannot buy rape-cake cheaply locally, ground-nut cake, containing 1½ times as much nitrogen and quoted at the same price as rape-cake, offers the best value at present prices.

Nitrate of soda is too expensive at present prices for general use, though useful for occasional application or when very rapid action is specially desirable.

For reasons of economy, the choice for general use is limited to Sulphate of ammonia and Calcium cyanamide.

Sulphate of ammonia has proved very valuable wherever used. It is well held by the soil and not unduly liable to loss by washing out. Its action is well distributed throughout the season. It has no adverse secondary effect, except that it uses up the lime in the soil, and therefore gradually increases soil acidity. Tea stands a very high degree of soil acidity, and will not grow normally well unless the soil is definitely acid. For many soils the increase of acidity from the use of sulphate of ammonia has proved a distinct advantage: for others already highly acid, the occasional use of lime would undo any possible

bad effect. After about 6 years continuous use of 200 lbs. sulphate of ammonia per annum, 10 mds. slaked lime would amply restore the lime lost to the soil.

Calcium cyanamide has also proved very efficient both in the experiment just quoted and in another where it has been applied continuously for 8 years. In some of these 8 years it failed to give quite as great an effect as the other forms of nitrogen tried against it; though in the last year (1931) it has given the greatest increase. Disappointment with its apparent effect has been expressed from several gardens. Its occasional poorer action is believed to be due to the presence of an impurity (dicyanamide) which has been found to an undue extent in some samples. The use of old stock, and of leaky drums in which the manure is found in a caked condition after wetting by rain water, are believed to be common causes for the presence of this impurity. Cyanamide also is a nuisance to apply, since it is irritant on wet skins; but it gives little trouble to those applying it, if their hands and forearms are wiped with an oily rag before work, and they wash immediately afterwards.

The element of danger in application, and the apparent uncertainty of its action have caused this manure to be less esteemed than its rival, Sulphate of ammonia. Still, from the evidence available to us, it does appear to give about the same effect in the long run, and to be free from danger in application if simple precautions are taken. It is, of course, possible that it may not suit all soils. Good samples on suitable soils are almost as rapid in action as nitrate of soda.

It has the property of leaving a residue of lime in the soil. On soils already bordering on under-acidity, this is a danger: on over-acid soils it must eventually prove an advantage.

One or the other should therefore suit any soil; while on soils considered to be naturally about right in acidity, sulphate of ammonia and cyanamide should be regarded as complementary.

The use of 200 lbs. sulphate of ammonia annually for two years, followed by 2 cwts. cyanamide in the third year, will leave

a soil just about as acid as it started, and the trouble and expense of a lime dressing can be avoided.

At present prices, having due regard to economy, only sulphate of ammonia or cyanamide among the artificials can be recommended; unless good oilcake is available locally at about Re. 1/- per maund in which case it should be preferred.

If a more delayed action than that of the 200 lbs. sulphate of ammonia applied in one dose (as this was) is desired, it can be obtained quite easily without having recourse to expensive organic manures, by applying half the total dose in February or March and the other half in June.

For example in a trial at Borbhetta extending over two years, 40 lbs. nitrogen as sulphate of ammonia added annually in March, gave the same crop increase within two years as the same total dose applied each year as 20 lbs. in March and 20 lbs. in June, but the full effect of the latter was deferred.

Sulphate of ammonia applied.	Increased crop compared to no manure in mds. tea per acre.						Total increase in crop.
	1930			1931			
	To end July.	August and Sept.	October and Nov.	To end July.	August and Sept.	October and Nov.	
200 lbs. in March annually	·62	1·02	·54	·98	·76	·62	4·54
100 lbs. in March and 100 lbs in June annually.	·31	·90	·45	1·16	1·09	·74	4·65

Dividing a small dose of artificial has given a delayed effect similar to that of using a slow-acting organic manure.

Organic Matter.

So far, the question of nitrogen supply, only, has been discussed. Apart from that, it is universely agreed that it is an advantage to maintain a reasonably high content of organic

matter in the soil. When a steady water-supply can be secured, (as in sand-cultures in a laboratory) plants can grow perfectly in pure sand with no organic matter, so long as all the elements necessary for growth are supplied as soluble artificials. From the evidence available it appears that organic matter is necessary in field soils only because to some extent it regulates water-supply to the plant. Put very simply, organic matter when the soil is wet holds water which is not available to plants, and as the soil dries, the drying organic matter changes in physical state so that it cannot hold so much, and liberates water which plants can use. Colloidal clay acts in a similar manner.

Very sandy tea-soils with little organic matter do very well until a prolonged drought occurs : then many cases are known where big patches of old established tea have died out, and many more cases where weakening by drought has allowed subsequent very serious damage by pest or blight.

The maintenance of a good content of organic matter reduces trouble from this cause. Many very coarsely sandy soils, rich in organic matter, behave as first class tea soils. In a clay soil, the defects due to close-packing and lack of aeration in wet weather can be improved by the flocculation of the clay due to the presence of organic matter in quantity; while clays cannot obtain water fast enough from the moist subsoil to help a drying surface soil, and organic matter then assists as it does in a sand. For example a really heavy clay with 12% loss on ignition is a first class tea soil, while another of similar mechanical analysis but with only 5% loss on ignition would yield less, on an average, with the same supply of available nitrogen.

Knowledge of these theoretical factors has led to a general preference for organic manures.

Borbhetta has a soil with about 65% sand and 5% clay, and having been very closely grazed for many years previous to planting with tea, is extremely low in organic matter. It is not as coarsely sandy as the most extremely sandy tea soils,

but it is distinctly a soil where benefit from ogranic matter might have been expected.

The results of two trials on this soil are very interesting :—

Yields in mds. tea per acre.

		1921	1922	1923	1924	1925	1926	1927	1928	1929	1930
No manure		7·3	8·0	8·7	7·4	7·5	6·9	5·8	3·8	5·8	5·6
Organic manures	Nervox	7·3	7·8	9·0	8·4	8·7	8·5	7·0	4·8	6·4	6·5
	Oilcake	7·2	8·6	10·5	8·9	10·0	8·9	7·9	5·9	7·6	7·5
	Boga medeloa cuttings	8·5	8·9	10·2	10·1	10·6	9·6	8·5	6·0	8·3	8·5
Soluble artificials	Sulphate of ammonia	6·9	8·1	10·0	9·1	10·2	9·3	8·8	5·9	8·1	8·1
	Nitrate of soda	7·6	9·1	12·0	9·4	10·4	8·8	7·9	5·6	7·9	8·3

In 1921 all plots were unmanured.

From 1922 to 1930 inclusive (9 successive years) each of the manures was given in quantity to supply 30 lbs. nitrogen annually.

During this time the increases over the unmanured check plots were :—

	1922	1923	1924	1925	1926	1927	1928	1929	1930
Nervox	·0	0·3	1·0	0 8	1·6	1·2	1·0	0·6	0·9
Oilcake	0·6	1·8	1·5	2·5	2·0	2·1	2·1	1·8	1·9
Boga medeloa	0·9	1·5	2·7	3·1	2·7	2·7	2 2	2·5	2·9
Sulphate of ammonia	0 1	1·3	1·7	2·7	2·4	3·0	2·1	2·3	2·5
Nitrate of soda	1·1	3·3	2·0	2·9	1·9	2·1	1·8	2 1	2·7

The plots did not start equal, the boga medeloa plots being originally above average, and the sulphate of ammonia plots below average. The experiments, also, being made in triplicate only, are not very accurate, but are accurate enough after so long a time to have allowed any superiority of the organic manures to have shown up, had they possessed any such superior properties.

In the first three years of application, nitrate of soda did remarkably well, after which it behaved irregularly. The continuous use of this manure undoubtedly causes loss of tilth of the soil, which has worse affects in some seasons than in others.

The apparent relative early failure of the sulphate of ammonia is probably due only to the fact that these plots started at a lower level of fertility than the others. This handicap was soon made up, and from 1925, onwards sulphate of ammonia has steadily done very well. No harm appears from the increase in soil acidity.

Taking the last five years, by which time most of the effect of initial difference in fertility should have worn off, the sulphate of ammonia plots have given an increase compared with no manure of 12.3 mds. against 13.0 mds. from the boga-medeloa-cutting plots. This is a very fine performance for plots on this soil to which no organic matter has ever been added, and the apparent small gain from the large quantities of organic matter added with the boga medeloa is certainly not significant, though the boga medeloa, which was cut and carried from outside the plots, has certainly performed consistently very well.

Oilcake, particularly in the last two years, has not done so well. It is doubtful whether the apparent relative inefficiency is really significant within the error of the experiment, but there is certainly no superiority to the soluble artificials.

The Nervox has done consistently, and quite significantly, badly.

The forms of nitrogen present in such manures as Nervox (sinews, hide, and hair) are definitely very inefficient as manure, even after a very long time, compared to soluble artificials, or to efficient organics like oilcake, or to such things as meat meal or blood-meal or fish-meal. Much of the nitrogen in cattle manure is similarly inefficient, as probably also is such material as hoof and horn which forms part of many animal meal mixtures.

II. Another trial compared animal meal, fish guano, and cyanamide, each manure being applied to give 30 lbs. nitrogen annually.

There has been no significant difference between the effect of the cheap cyanamide, and that of the two very expensive organic manures. In some years the cyanamide has done rather less well than the others, but in 1931 (the eighth year of application) it is actually doing better.

In another place at Borbhetta, yields as high as 20 mds. tea per acre have been maintained with soluble artificial alone, with no addition of organic matter since the tea was planted eleven years ago.

It is fair to conclude that the addition of organic matter from outside sources has proved unnecessary. The tea on none of these plots is shaded, but several tons of organic matter in the form of prunings have been added from the tea bushes themselves, and it must be assumed that this has proved sufficient. It is believed that this conclusion may be applied to all close-grown tea, more particularly if it is shaded, and that there need be no fear of harm from failure to supply additional organic matter.

Among young tea or very poor tea, where there will be room for growth of shrubs like boga medeloa, such green crops should prove valuable not only for the nitrogen they supply, but for their content of organic matter also. Where additional organic matter in a soil is desirable it can be supplied both in greater quantity, and much more cheaply as green crops, leaf-fall from shade trees, or as cattle manure, than as expensive concentrated organic manures.

The necessity for continuous manuring.

If the results of the longer continued experiments at Borbhetta be referred to, it will be observed that the results from manuring are generally cumulative: that is, for a few years

the increases from manured plots compared to unmanured plots become progressively larger. For example about 8 mds. oilcake which gave 0.6 mds. increase in the first year increased its lead till for the past six years it has given about 2 mds. increase. Similar about 5 mds. fish guano, gave no increase at all in the first year of application (when the tea was cut-back and long initial growth given) and 1.2 mds. increase in the next year, but steadily increased its lead till it gave a roughly steady increase of about 3 mds. per acre from 1929 to 1931 inclusive.

This is not only the residual effect of a slow acting organic manure. The results from calcium cyanamide are similar to those from the fish manure, and those from sulphate of ammonia show an even stronger tendency to cumulative increase than do those from oilcake (p. 178).

In another experiment continued over three years, the following results were obtained from annual application of 200 lbs. sulphate of ammonia.

	Mds. tea per acre.		
	1929	1930	1931
Manured plots	10·54	10·65	13·75
Unmanured plots	8·06	7·44	9·75
Increase in crop ...	2·48	3·21	4·00

The manured plots in 1929 and 1930, consisted of 10 sets of 6 plots each, all sets giving the same crop. In 1931, after manuring in 1929 and 1930, the manuring was stopped on 5 sets of 6 plots, and continued on the other 5 sets of 6 plots.

The results of the continuous manuring are given above. The plots left unmanured in 1931, after manuring in 1929 and 1930, gave 11.65 mds. tea per acre, or 2.1 mds. less than the plots on which manure was continued in 1931. The loss from stopping the manuring for one year is therefore just about as

much as would be gained in the first year of manuring previously unmanured plots.

It is very interesting to note that these plots which were manured for two years only and then not again, do not immediately drop back to the yield of the plots never manured. Although analysis has failed to detect any residue of nitrogen in the soil from the previous manuring, the bushes are left in so much better condition, and so much bigger, that they continue to yield better, although manuring is stopped.

Similar cumulative effects occur even with very large applications of manure. For example, plots to which 120 lbs. nitrogen per acre have been applied for eight successive years, now give 13 mds. more tea per acre than the unmanured check plots, although the increase from 120 lbs. nitrogen in the first year is only about 6 mds.

It appears that the earlier applications of nitrogen are used only partly in giving increased crop, and are very largely used in building up better and better bushes, until a roughly steady level of fertility is maintained. If manuring be then stopped, the drop from the high level of yield is probably just about as fast as was the building-up process.

As a result of the cumulative effect, the later applications of manure show a very much bigger profit than do the earlier ones. Occasional manuring misses this cumulative effect, and fails to pay a full profit. If manuring be increased, and then diminished, the temporary increase must similarly fail to yield a full return.

It is advised therefore that the attempt should be made to supply about the same quantity of nitrogen annually, though the amount to be supplied may be as great or as little as desired. It is not necessary that the nitrogen should always be supplied as artificial. The use of reasonably spaced shade trees appears to give about as much effect as 30 lbs. nitrogen annually as artificial, and leguminous trees alone will maintain a certain level

of fertility. Green crops, cattle manure, and top-dressing should be used in addition, so far as their use is likely to prove cheaper than artificials under the particular local conditions, and the balance necessary to maintain the desired level of fertility should be supplied as cheap, and efficient, soluble artificials.

This desired level of fertility generally would be that which produces an average yield about equal to the crop of fine leaf which can be plucked, at intervals exceeding seven days only rarely. Intervals of 6 days would be preferred for really good tea.

Summary.

It has been shown that nitrogen is the element of chief importance in the food supply of the tea bush, and it is considered safe to apply nitrogen only, without potash or phosphoric acid for one year at least, and probably for several years. This will effect a considerable economy in manuring in the immediate future at least.

Leguminous trees are considered to be of great value as cheap suppliers of efficient nitrogen, and to be reasonably free from countervailing disadvantages if planted not closer than about 50 ft. apart.

Shrubs like boga medeloa are shown to be of great value in tea among which there is room for growth, but are considered undesirable among close-grown bushes in full yield.

Ground green crops like cowpeas are considered not generally to pay, in comparison with cheap soluble artificials at their present low prices.

Cattle manure is shown to be relatively inefficient and expensive, but is advised for occasional application, particularly as part of the cost of collection is a necessity for the purpose of cleaning lines.

Top dressing can be recommended only where first class material is available near at hand.

The expensive organic manures are shown to be at best no more efficient, even after many years, than cheap soluble artificials; while several forms of organic manure are considered to be definitely inefficient. Of the soluble artificials only sulphate of ammonia and calcium cyanamide can be advised at present prices. Of these, sufficient to supply 30 lbs. nitrogen annually per acre, that is 150 lbs. sulphate of ammonia or 160 lbs. calcium cyanamide, either costing about Rs. 8/- in Calcutta is sufficient to maintain reasonable yields when applied to good tea.

40 lbs. nitrogen would be preferred for general use where a gradual slow improvement is desired to counterbalance loss from other causes. If loss of June quality is feared from too great an increase in the rate of early growth, the total of 40 lbs. nitrogen per acre, may be applied at 20 lbs. in February or March and 20 lbs. at any convenient time about June.

Occasions for the use of larger quantities will be discussed in the next issue of this Journal.

It is considered that manuring should be continuous, which means that every section should be manured every year, and that it should be attempted to supply about the same quantity of nitrogen annually, not necessarily always in artificial forms.

EFFECT OF MANURING ON SOIL TILTH

BY

H. R. Cooper.

In a series of experiments (described in more detail on page 178 of this Journal), the effects on crop of the following manures were compared—(1) Nervox, (2) oilcake, (3) sulphate of ammonia, (4) nitrate of soda, and (5) green cuttings from boga medeloa (carried from outside the manured area).

Quantities of manure were added so that each supplied 30 lbs. nitrogen per acre in 1920, and from 1922 to 1930 inclusive. All the plots became attacked by stem disease, fell off in yield from about 1925, and continued to yield poorly. Very light plucking in 1928 failed to effect much improvement during 1929 and 1930. In 1931 therefore it was decided to increase the manure application to all the manured plots from 30 lbs. per acre to 80 lbs. per acre, to see whether relatively heavy manuring would restore good yields in spite of the presence of the disease.

By March 1931, then, all the manured plots had received a total of 380 lbs. per acre of nitrogen in one of the five selected forms.

The nitrate of soda plots yielded very well indeed for about 3 years, and then began to yield irregularly and relatively poorly, and it was observed that they showed an abnormal number of poor bushes carrying many dead upper branches. New, but often poorly developing, shoots usually arose below the dead portion of the branch. Yellowish and blackened leaves also began to be common.

It was thought that a difference in tilth could be observed—the soil after hoeing lying in tougher clods, with more polished cut surfaces.

As there was a distinct possibility that this might be due to the effect of the soda in defloccuting the clay, samples of soil were shaken with water and allowed to stand. As the soil of the

nitrate of soda plots gave very distinctly more turbid suspensions, it was decided to get a rough comparison of the amount remaining in suspension, after shaking samples from all the plots with water.

The following procedure was adopted :—

Seven borings from evenly distributed points on each plot were taken, to 9″ depth, with an earth auger. Each set of 7 borings was bulked. From each bulk a 10 gram sample was taken. This was put in a 300 ccs. flask and shaken for 15 minutes with 200 ccs. distilled water. The whole of the turbid suspension of soil in water was then poured into gas-cylinders of 2″ diameter, and allowed to stand for 96 hours.

Differences in turbidity showed up to the eye very strongly every day. At the end of 96 hours; a 20 cc. sample was withdrawn with a pipette at a depth 7½ cms, from the surface of the liquid. This 20 cc. sample was evaporated to dryness and the residue weighed.

The figures quoted are the means of duplicate weighments in grammes, multiplied by 100.

As the experiment in the field was conducted in 3 blocks, each containing each of the six different treatments, Fisher and Wishart's method* of calculating the significant difference is applicable.

The following results were obtained :—

	Nervox.	Oilcake.	Sulphate of ammonia.	Nitrate of soda.	No manure.	Boga medeloa cuttings.
Block 1 ...	1·3	0·7	0·6	2·3	1·3	1·0
Block 2 ...	2·9	1·5	1·0	2·1	1·3	1·6
Block 3 ...	2·2	1·4	1·0	2·4	1·3	1·4
TOTAL ...	6 4	3·6	2·6	6·8	3·9	4·0
mean ...	2·13	1·20	·87	2·27	1·3	1·33

Standard error = 0·19
Significant difference = 0·57

*R. A. Fisher and J. Wishart—Imperial Bureau of Soil Science, Tech. Comm. No. 10. London, May, 1930.

Oilcake and boga medeloa have made practically no difference compared to no manure.

Sulphate of ammonia has apparently increased the rate of settling of the suspension. Such an effect might have been expected since this manure has considerably increased the acidity of the soil, and the effect appears to occur in practice from the following example.

On certain plots at Borbhetta the effect of nitrate of soda in varying quantities was being tried. After 5 years of continuous addition, 800 lbs. nitrate of soda was found to be giving less crop than 400 lbs., and the bushes receiving the higher dressing were very clearly more diseased. In the sixth year sulphate of ammonia was substituted for nitrate of soda, with such good results that the difference in degree of disease attack disappeared, and the higher application of nitrogen produced increasingly larger crops, in the sixth, seventh and eighth year of application of nitrogen.

However, the particular set of experiments now described is not sufficiently accurate to demonstrate this effect of sulphate of ammonia with certainity, since the difference between the average figure from the sulphate of ammonia plots and that from the unmanured plots is less than the calculated significant difference.

A new series of similar experiments where each treatment is repeated seven times, should, in time, decide the question.

Nitrate of soda. The figures relating to the soils from the nitrate of soda plots show a difference from all but the Nervox soils which is significant, so that the supposition that these plots had become more sticky than the average is confirmed.

Nervox. These plots also show a significantly greater stickiness than all the plots except the nitrate of soda plots. This had not been suspected until the soils were shaken with water. The plots had always yielded poorly, presumably because

of the difficulty of decomposition of the nitrogen compounds present, and had not been specially examined.

The only explanation which can be suggested, as to the cause of the difference found, is the presence in the soil of small quantities of a protective colloid arising from the manure used.

Since the manure consists mainly of sinews, bone, and hide it is possible that this protective colloid may be gelatin.

CATERPILLAR PESTS OF THE TEA PLANT, AND OF GREEN MANURE PLANTS AND SHADE TREES IN USE ON TEA ESTATES

BY

E. A. ANDREWS.

Part III.

The Bunch, or Cluster Caterpillar.

(*Andraca bipunctata*—Wlk.).

The Bunch caterpillar has the distinction of being the earliest recorded pest of the tea bush, having been recorded as a pest of tea in Formosa by a Chinese Governor of that island as long ago as 1820.* It was apparently, also, one of the two first, if not the first, pest of tea to be recognised as such in North-East India, for S. E. Peal, in the "Tea Cyclopaedia", published in 1881 (page 34j), after referring to the order in which the principal pests of tea come to notice,, writes "Caterpillar and "Borer were known some little time before", and for some years the pest was referred to simply as "Caterpillar", there being apparently no rival caterpillar pest to make further description necessary. The insect was described, and given its scientific name, so long ago as 1865,† at which time the tea mosquito bug had just been recognised as a pest of tea in Cachar and Darjeeling. This early recognition of the insect as a pest was undoubtedly due to its habit of stripping the bushes of leaves, and so making them conspicuous in the plucking area, together with its habit of congregating on the branches of the bushes in conspicuous clusters during the day, for in 1881 Peal, in listing the then known pests of tea, includes the insect in "the list, so far "as I know it," of insect blights or pests "that are not really of "serious moment".

It is of passing interest to note that the Bunch caterpillar is a silk-worm. In India there are several varieties of silkworm under domestication, belonging to two distinct families of moths,

*Shiraki, T.—"Preliminary Report on Insect Pests of the Tea-Plant in Formosa," Proc. IIIrd. Entomological Meeting, Pusa, II, 666. 1920.

†Walker, Cat. Lep., XXXII, p. 582.

and one representative of each family has been found to attack tea. The indigenous silk-moths of India belong to the family *Saturniadae,* and include among others the well-known Eri silk-moth (*Attacus ricini,* Boisd.), Muga (*Antherea assama,* Westw.), and Tasar, or Tussore (*Antherea paphia,* L.), and that minor tea pest the Cricula silk-worm (*Cricula trifenestrata,* Helfer). This family also includes the Atlas moth (*Attacus atlas,* L.), which will feed on tea, and occasionally does so in Ceylon, but seldom in North-East India. The common silk-worm of commerce (*Bombyx mori,* L.), now in common cultivation in Japan, India, and the Mediterranean countries, but which was originally introduced from China, belongs to the family *Bombycidae,* and it is to this family that the Bunch caterpillar belongs. The silk cocoon spun by the latter, is, however, a poor thing, and useless for commercial purposes.

Bunch caterpillar, like the Looper, passes through four generations in the year in North-East India, but its development is not quite so straightforward as in the case of the latter, and there is a greater tendency to overlapping of successive generations. Shiraki states that there are three generations in the year in Formosa, and this is apparently due to differences in climatic conditions, for in Formosa the duration of each life-cycle is considerably prolonged, and there is no evidence in Shiraki's records of the protracted rest in the pupal state which occurs during the cold weather in North-East India. Temperatures, in Formosa, are lower, and climatic conditions more regular throughout the year, and development of the insect is therefore slower, but also more regular over the annual cycle.

The eggs of the moth of the bunch caterpillar are usually deposited on the underside of the leaves of the bush, in regularly arranged groups. The eggs themselves are regularly oval in shape, with a smooth unornamented shell, and yellowish-drab in colour. One end of the shell is closed by a circular cap, which is pushed open by the young caterpillar when it emerges. The arrangement of the eggs in each group is characteristic, the group consisting of a series of parallel rows of eggs, in which

the eggs are placed side by side, with the caps all facing the same way. The rows are generally straight and very regular, but occasional irregularities occur, and the ends of the rows are sometimes curved inwards, while occasional eggs, generally towards the end of a row, may be laid somewhat out of position. Each group is placed on one side of the midrib of the leaf, and the rows lie at an angle to the midrib. Thus the groups of eggs are characteristic, and easily recognised. Occasionally eggs have been found to have been deposited on the stems of the plant, but this is exceptional, and in captivity eggs are sometimes deposited singly, but in all cases these have been found to be infertile, and the phenomenon appears to have been induced by unfavourable conditions. The eggs of this insect are much larger than those of the looper moth, measuring 12 millimetres in length with an average of 10½ millimetres in breadth. The number of eggs in a group, and the number of eggs per row, may vary considerably. Groups have been observed consisting of as many as 100 eggs, but the numbers of eggs in the groups range generally between 25 and 80, with exceptional numbers up to 100 and down to 6. The following details of the arrangement of the eggs in four typical groups give a fair idea of the variety in arrangement.

1st. group—4 rows.

Front	row	14	eggs
Next	,,	12	,,
,,	,,	10	,,
Back	,,	14	,,
Total		50	,,

2nd. group—5 rows.

Front	row	4	eggs
Next	,,	6	,,
,,	,,	8	,,
,,	,,	6	,,
Back	,,	1	,,
Total		25	,,

3rd. group—9 rows.

Front	row	2	eggs
Next	,,	5	,,
,,	,,	1	,,
,,	,,	7	,,
,,	,,	9	,,
,,	,,	9	,,
,,	,,	4	,,
,,	,,	7	,,
Back	,,	4	,,
Total		48	,,

4th. group—16 rows.

Front	row	3	eggs
Next	,,	3	,,
,,	,,	3	,,
,,	,,	3	,,
,,	,,	3	,,
,,	,,	4	,,
,,	,,	4	,,
,,	,,	4	,,
,,	,,	5	,,
,,	,,	3	,,
,,	,,	5	,,
,,	,,	5	,,
,,	,,	5	,,
,,	,,	4	,,
,,	,,	7	,,
Back	,,	8	,,
Total		69	,,

One female, typically, deposits two or three groups of eggs, but as many as five groups have been deposited by one female. The usual number of eggs laid by one female ranges between 150 and 200, but some have laid more than this, the highest number deposited by one female being 292. The female, when

she emerges from the chrysalis, is ready for immediate fertilisation, and this often occurs. In such cases eggs may be laid two days after the emergence of the female moth. Fertilisation can, however, be delayed for two days, after which, if unfertilised, the female generally deposits a few infertile eggs and dies. Should fertilisation occur on the second day after emergence, eggs are generally deposited two days later, that is, four days after emergence. One case occurred, however, in which fertilisation was delayed for two days, and egg-deposition did not commence until the fifth day after, seven days after the emergence of the moth. Thus, whereas deposition of the eggs generally commences from two to four days after emergence, it may, on occasion, not commence for a week. In the majority of instances all eggs were deposited on the same day (or rather night, for this insect, like the looper, is mainly nocturnal), but egg-laying is commonly spread over two or three days, and occasionally over four.

When the caterpillar is ready to emerge, generally after ten or eleven days, the egg loses its yellow colour, and becomes colourless and translucent in appearance, owing to the withdrawal of the contents of the egg from contact with the shell, and the presence of air between the shell and the membrane beneath it. The caterpillar pushes off the circular cap at the end of the egg, and emerges as a light yellow caterpillar about a fifth of an inch long, with the head and first segment of the thorax dark blackish-brown, and covered with prominent stiff hairs, which are particularly long and stout on the head and thorax. After emergence the young caterpillars make a meal of the empty egg-shells, and then migrate to the underside of a leaf, when they congregate, and feed on the under part of the leaf, leaving the upper epidermis untouched. In this stage the caterpillars do not congregate on the stems, but cluster together during the day on the underside of the leaf, which becomes covered with a tangled mass of silk strands. This stage lasts for periods varying from five to seven days in April, two to five days in June, five to seven days in August, and five to eight days in November.

The caterpillar then undergoes a moult, and the second stage emerges, at first about three-tenths of an inch long, finally attaining a length of five-eighths of an inch. In this stage the yellow ground-colour is retained, but the caterpillar is marked by five light-brown longitudinal lines, a narrow one down the middle of the back, and two broader ones on each side, each broken at the junctions of the segments of the body. This causes the caterpillar to have a brownish appearance to the naked eye. The head and first segment of the thorax are very dark brown, and the long hairs on the body have disappeared, giving place to the short downy hairs which persist until the caterpillar is full grown, and give it a velvety feel to the touch. In this stage the caterpillars still congregate mainly beneath the leaves, but they commence to bite the leaves from the edges. This stage lasts for from five to eight days in April, four to five days in June, five to eight days in August, and six to eleven days in November and December. In one exceptional case the caterpillars took ten days to pass through this stage in June.

A second moult is now undergone, after which the insect emerges in a form much resembling the full-grown caterpillar, though as yet only half an inch long. The yellow ground-colour is still present, but beginning to be obscured by the further development of the longitudinal brown bands, which are now much darker in colour and much broader. These bands are, however, still broken by fairly wide gaps at the junctions between the body-segments, which makes them irregular, and gives the caterpillar a "marbled" appearance. The breathing orifices are now distinctly marked, as the immediate area round each orifice is coloured dark brown. In this stage the insects form typical clusters on the branches, and though the damage done is as yet not sufficiently extensive to make the bushes conspicuous in the plucking area, the clusters are often sufficiently prominent to be conspicuous of themselves. The caterpillar attains a size of about three-quarters of an inch by end of this stage, which occupies four to seven days in April, five to six in May, three to five in June, five to eight in August, and seven to nine

(occasionally longer, to as many as fifteen) days in November and December.

The next moult gives rise to the fourth stage larva, which is similar, in all respects but size, to the full-grown caterpillar. The head and the segment immediately behind it, as in all stages, are brownish-black. The ground colour of the body is now a tawny yellow, but much obscured by two broad brown longitudinal bands, broken as in earlier stages, which run, one on each side of the body. Down the middle of the back, between the bands run three prominent longitudinal yellow lines, and on each side two longitudinal yellow lines show up in the brown band. In this stage the caterpillar grows to be a little over one and three-quarter inches in length, and begins to eat away the whole leaf to leave nothing but the leaf-stalk in the manner characteristic of the full grown caterpillar. This stage occupies from four to seven days in the period from April to September, and six to eleven days in November, December, and January.

The insect then undergoes a fourth moult, and the last caterpillar stage is reached. Immediately after emergence it is about two inches in length, attaining a length of two and a half inches, with a body thickness of a quarter to five-sixteenths of an inch. The markings are really similar in design to those of the previous stage, but the brown bands are now so widely interrupted that they have the appearance of broad transverse bands, crossed by the longitudinal yellow lines. The whole caterpillar has also taken on a more reddish tinge, both the brown and the tawny ground-colour being affected. The depredations of the insect are by this time very conspicuous. The leaves are eaten completely off, leaving only the stumps of the leaf-stalks, and the amount of food devoured is indicated by the mass of black droppings below the bush. In the case of populous colonies a whole bush may be stripped in one night, for feeding is done at night, and the caterpillars congregate together in clusters on the stem during the day. These clusters are very conspicuous and characteristic, the insects being so closely intertwined that it is often impossible to make out which is head and which is tail.

There is undoubtedly some benefit to the insect in this association, though exactly what it is difficult to make out. It has been observed, however, that the caterpillar finds some difficulty in voiding its excreta, which issue as a very large, irregularly round, hard ball, and that it is the habit of another individual in the colony to reach out, grasp the ball, when a little more than half-extruded, with its jaws, and assist, so it is evident that the insects are dependent on each other to some extent. The duration of this last caterpillar stage varies between four and seven days in June and July, four and eight days in May and September, and eight and thirteen days in December and early January.

When full-grown the caterpillars leave the bush and descend to the ground to form the chrysalis, or pupa. This is generally formed at the surface of the soil, among dead leaves and other rubbish lying about. Before pupating the caterpillar spins a silken cocoon for protection. These cocoons are irregularly torpedo-shaped, spun from dirty-brown coloured silk, in part loosely woven, in part woven more closely so that the texture of the cocoon cannot better be described than that of unglazed tissue paper. The length is in general about one and a quarter inches, the breadth half an inch, In this stage, however, the insect retains its gregarious habit, with the result that the cocoons occur in groups of several woven so closely that they adhere together, and in consequence become flattened on all sides. The pupa itself is smooth, about an inch in length, and reddish-brown in colour, of the typical kind described in the first of this series of articles, the wings and appendages being glued down so closely as hardly to disturb the general smoothness of the surface. The time of duration of the pupal stage is very variable, not only at different times of the year, and not only in individuals belonging to different clusters, but also among members of the same cluster. It is in consequence of this variation that the considerable overlapping of generations, referred to earlier in this note, is found to occur. For example, the members of the last (fourth) generation of the season, as a general rule, are ready to begin pupation by the end of November or early December, and

the moths from these pupae do not emerge until the following March, the time spent in the pupal stage varying from sixty-eight to one hundred and twenty days, but one extreme case was observed in which development had been delayed to such an extent that pupation of the fourth generation did not occur until the end of February, the adults emerging at the usual time, in March, after a pupation period of only 19 days. During the season the times spent in the pupal stage vary rather curiously, this stage being passed through more rapidly in the first and third generations than in the second and fourth. In April, May, and early June this stage may last for from sixteen to twenty-nine days, and in September and October twenty-nine days has also been the maximum period so far recorded. Fron the end of June to the beginning of September, however, pupation may take as long as forty-six days. This peculiarity may be connected with a necessity for inter-fertilisation between the members of different clusters in every alternate generation, for in the insectary it has been found in all cases that while it is perfectly easy to rear a second generation from one cluster, the eggs laid by females of the second generation, even after copulation with a male has been observed, are always infertile. The females are ready to accept the male almost directly they emerge, and copulation often takes place on the night of emergence. Moreover, in the majority of cases the adults which emerge during the first two or three days are found to be males, and as the male also emerges ready for immediate copulation this would appear to be a provision to ensure that males from one cluster should migrate in search of females, and thus interbreed with females from another cluster. In such event it is obvious that a considerable degree of overlapping of generations is essential for the preservation of the species.

The adults are inconspicuous brown moths, and, as they fly mostly at night, and are not in the habit of coming to light, are seldom observed. The female is a stout-bodied moth, the total length of the body from head to tail being three-quarters of an inch, and the average breadth one quarter of an inch, while

the wing expanse, from tip to tip of the extended fore-wings, is from two and one eighth to two and three-sixteenths of an inch. The outer margin of the fore-wing is incised just below the point of junction with the front margin, so as to form a distinct tip to each wing. The general colour of the wing is light brown, with the tip darker brown, and three irregular dark-brown bands crossing the wing transversely. The outer band, which is almost always the most distinct of the three, commences at the tip and crosses to the hind margin of the wing, taking a curve in towards the body of the moth on the way. The middle band stretches across the middle part of the wing from the front to the hind margin, and the two (one on each wing) correspond almost exactly in shape with the two orifices on the front of a violin. The inner band, nearest the body, also stretches from the front to the hind margin, taking a curve towards the outer margin of the wing. This band is generally waved, often very indistinct, and sometimes practically absent. The hinder two-thirds of the hind-wing is of the same brown colour as the fore-wing, but shades anteriorly into a tawny colour. There are two waved convex darker brown bands, practically concentric with the outer margin, crossing the hind-wing from the front to the hind margin. The antennae, or feelers, are simple. The male moth is smaller, the expanse of the extended fore-wings being one and five-sixths inches. The body is about half an inch long, narrower, and tapering towards the posterior extremity, and the general colour is a darker, and more reddish, brown. There is a distinct tip to the fore-wing, though it is not so marked as in the female, and the same darker bands cross both wings, but are much less distinct. The hind-wing, also, is of a uniform dark-reddish-brown colour, without the lighter area in the anterior third of the wing. The antennae are conspicuously plumed, but not quite to the tip, which has the appearance of a short fine filament stuck onto the end.

The period during which moths are emerging has been found to extend over a fortnight in the case of those which are to begin the second and fourth generations, though

in the case of the latter it is probably longer in the field, while during the height of the season (July to the beginning of September) it extends over three weeks, and at the beginning of the season, when the over-wintering moths of the last generation of the previous season are emerging, emergence may occur over a period of five weeks during March and April. Details regarding egg-laying have already been given when discussing the egg of the insect, and need not be repeated here. The female dies a day or two after deposition of the last batch of eggs, the male dying at about the same time or sooner.

The typical life-cycle of this insect throughout the year may be summarised roughly as follows.

Moths emerge from the middle of March to the end of the first week of April.

Eggs are laid from the middle of March to the second week of April.

Caterpillars are emerging from the end of the third week of March to the middle of April.

Pupation is taking place from the third week in April to the middle of May.

Moths emerge from the middle of May to the end of the first week of June.

Eggs are laid from the middle of May to the second week of June.

Caterpillars are emerging from the end of the third week in May to the middle of June.

Pupation is taking place from the third week in June to the middle of July.

Moths emerge from the middle of July to the end of the first week of August.

Eggs are laid from the middle of July to the second week of August.

Caterpillars are emerging from the end of the third week in July to the middle of August.

Pupation is taking place from the third week in August to the middle of September.

Moths emerge from the middle of October to the end of the first week of November.

Eggs are laid from the middle of October to the second week of November.

Caterpillars are emerging from the end of the third week in October to the middle of November.

Pupation is taking place from the third week in November to the end of December.

Moths emerge from the middle of March to the end of the first week in April.

The above summary outlines what happens in mid-Assam in the majority of instances, but owing to the considerable overlapping of generations which occurs exceptions will frequently be noticed.

A noticeable feature of the bionomics of bunch caterpillar is the great variation in numbers from year to year. The insect will suddenly turn up in large numbers one year, where it has been little but a curiosity before, and again, next year, be so reduced in numbers as to be little more than a curiosity once more. The reason for this is obscure. It has been put down to climatic variations, and it may be somehow connected with the prevalence of an obscure bacterial disease which attacks the caterpillar. Bunch caterpillar, however, has also been found to occur on two other plants common in North-East India. The first is the common wild rhododendron, called by the Assamese "futuka" (*Melastoma malabathricum,* Jack), and the second a shrub known in Assam as "murmuri", or "mulmooriah" (*Eurya japonica,* Thunb.). It has been observed that in some years, when the insect is scarce on the tea, it is to be found in considerable numbers on futuka, and this would appear to point to the fact that the question of suitable food supply may come into the matter. Certainly no climatic condition, common to all instances, can yet be cited. In the case of the bacterial disease

the caterpillars all die in the last stage, before the stage of pupation is reached, and so far no case has been found of transmission through the egg, as in the case of the pebrine disease of silkworms.

As in the case of looper, insecticides are not recommended for dealing with this pest, as there are two obvious methods of dealing with it which are more effective and much less expensive. To spray the whole area, in the case of a gregarious insect so localised in its area of attack, is obviously unsound. If a contact insecticide be considered, to spray the clusters on the bushes after they have been located, it is evident that it is much simpler, and less expensive, to collect and destroy each cluster. The time at which this is most efficient is when the first brood is on the bushes in March and April. Not only does this destroy the ones collected and their possible descendants, but it much reduces the chance of the emergence of males of one colony coinciding with that of females in another, and results in many eggs laid by the next generation being sterile. There is not much object in looking for egg-clusters, or for the groups of the younger stages of the caterpillar beneath the leaves, as the damage done up to that time is negligible, but directly clusters of the small third stage caterpillars are observed a systematic search of the area should be instituted. If this be done thoroughly no other measure need be taken until the cold weather, when any belated clusters of the caterpillars should be collected and destroyed during the pruning, and cocoons turned up by the forking people collected and destroyed likewise. In this connection the following quotation from Watt and Mann's "Pests and Blights "of the Tea Plant" may be of interest.

"Mr. J. A. Thomson" (then manager of Ligri Pukri) "was "in the habit of sending specially trained men in Autumn to mark "down the bushes on which the caterpillar had been feeding. "These can at once be recognised by the large quantity of their "droppings that may be seen on the surface of the soil. On the "bushes being so marked, a few coolies were told off to remove "soil round the stem with their kodallies. They have little diffi- "culty in picking up the cocoons from the soil thus turned over."

Several managers have informed the writer that in spite of searching, they have never found bunch caterpillar on futuka. Further records of this would be gratefully received. In searching it should be remembered that the insect tends to be prevalent on futuka when scarce in the tea, and *vice versa*. It is an established fact that the insect does feed on futuka. Not only have we numerous records of its occurrence, but we can regularly collect the insect from this plant, and rear it to maturity on cuttings of futuka, and eradication of this plant from the neighbourhood of tea estates is certainly indicated where the insect is prevalent.

TURNING PROGRAMME, 1932.

Month.	P. H. Carpenter.	H. R. Cooper.	C. R. Harler.	C. J. Harrison.
January ...	.....	.....	.....	.....
February ...	Happy Valley.	.....	.....	Nowgong and Kamrup.
March ...		.....	Tingri and Naharkatia.	H
April ...	Tezpore and Orang.	Doloi, Juri, Lungla.	.....	O M
May ...	Moran and Nazira.	.....	.....	E
June ...	Eastern Dooars.	.....	Doom Dooma and Margherita.	L
July ...	.....	.....	.....	E
August ...	.....	Chargola and Longai.	Daina Toorsa.	A V
September ...	.....	Dibrugarh and Panitola.	N. Darjeeling and Terai.	E
October ...	.....	Behali and Bishnath.	.....	.....
November ...	.....	.....	.....	.....
December ...	.....	.....	.....	.....

N.B.—The other Officers of the Department will tour only as the investigations that they are carrying out necessitate.

The exact dates of the above tour will be given later to the Sub-District Chairmen. Managers desiring a visit from the Scientific Officer must inform the Sub-District Chairman who will make out a tour itinerary.